ENVIRONMENTAL AND SOCIAL IMPACT MONITORING OF THE BUJAGALI HYDROPOWER PROJECT (BHPP), UGANDA FISHERIES COMPONENT

Monthly Patterns in Physico-chemical Conditions and Fish Catch in the Immediate Vicinity of the Bujagali Hydropower Construction Site

29th September - 28th October 2007

Prepared for Bujagali Energy Limited (BEL)

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1. INTRODUCTION

Following the commencement of construction works of a 250 MW hydropower plant at Dumbbell Island in the Upper Victoria Nile in September 2007, BEL requested NaFIRRI to conduct continuous monitoring of fish catches at two transects i.e. the immediate upstream transect of the project site (Kalange-Makwanzi) and the immediate downstream transect (Buyala-Kikubamutwe).

The routine monitoring surveys were designed to be conducted twice a week at each of the two transects. It was anticipated that major immediate impacts were to occur during construction, and these needed to be known by BEL as part of a mitigation strategy. For example, the construction of a cofferdam could be accompanied by rapid changes in water quality and quantity downstream of the construction. These changes in turn could affect the fish catch and would probably be missed by the quarterly monitoring already in place. Therefore, a major objective of the more regular and rapid monitoring was to discern immediate impacts of construction activities by focusing on selected water quality parameters (total suspended solids, water conductivity, temperature, dissolved oxygen and pH) and fish catch characteristics (total catch, catch rates and value of the catch).

2. SPECIFIC OBJECTIVES

2.1. WATER QUALITY

1. To measure the water physical variables as indicators of environmental conditions in the upstream and downstream transects of Kalange (1) and Buyala (2), respectively,
2. To determine the concentrations of total suspended solids as a major constituent likely to be released into the waters at any time during the construction activities, by comparing the concentrations at the two transects.

2.2. FISH CATCH

1. To follow up trends in fish catch as construction activity progresses, and to increase precision of the estimate;
2. To estimate the prevailing fish catch rates, total fish catches and the total value of the fish catch to the local fishers at the two transects.

3. MATERIALS AND METHODS

Study Area

The routine surveys are being carried out at two Transects: Transect 1 (Kalange-Makwanzi) and Transect 2 (Buyala-Kikubamutwe) (Fig. 1). Transect 1 lies upstream of the construction site at Dumbbell Island while Transect 2 lies downstream of the construction site.

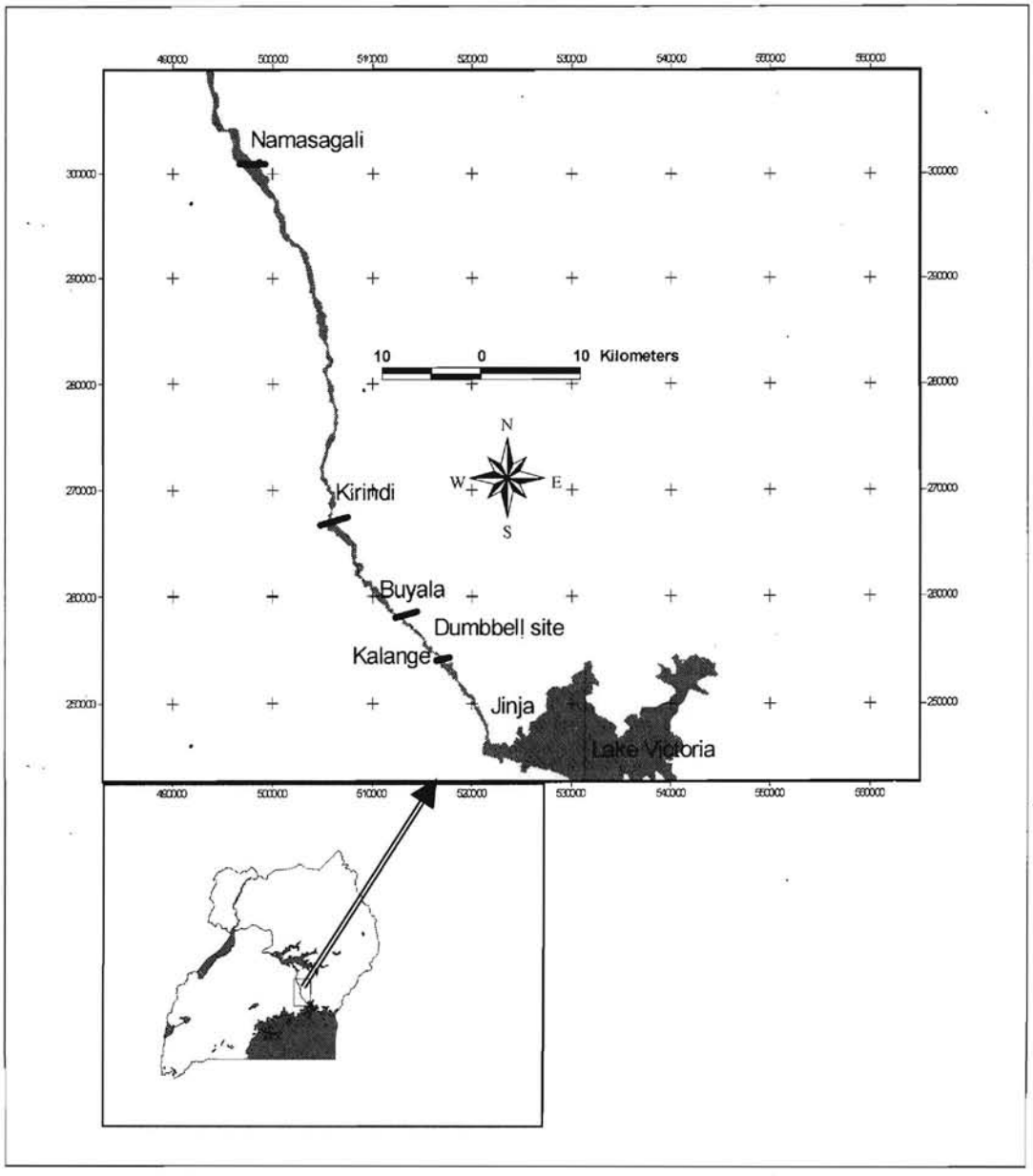

Fig. 1: Monthly sampling Transects at Kalange-Makwanzi and Buyala-Kikubamutwe (upstream and downstream of Dumbbell site on the Upper Victoria Nile River.

4. FIELD PROCEDURES AND ANALYSIS

4.1. WATER QUALITY

Sampling at Transects 1 and 2 along the upper Victoria Nile was conducted on different dates during September and October 2007. The period was generally characterized by rains. Sampling was often conducted on dry days, after rains on previous days or immediately after it had rained. The physical-chemical variables measured *in situ* were water conductivity (µs/cm), temperature (^{o}C), dissolved oxygen (mg/L), pH, water depth (m) and secchi depth (m). The measurements of all the variables except the last two were done at 0.5m below water surface, using calibrated standard portable meters, at three stations (east, mid and west) of each transect, across the river. The secchi and entire water depths (m), in all the stations were measured using a standard secchi disc and an echo sounder, respectively. Water samples for determination of total suspended solids (TSS) were collected from a depth of 0.5 m using a Van Dorn sampler. Water samples were transferred from the Van Dorn sampler to clean plastic sample bottles. The samples were placed in cool boxes containing ice blocks and transported to NaFIRRI laboratories for analyses.

The total suspended solids (TSS) in water were determined by weight difference, following the standard methods as specified by Greenberg *et al.* (1992). The initial weight of an oven-dried filter paper (Whatman GCF) was obtained before filtering through it a known volume of water for the suspended solids. The filter paper containing the solids was dried to a constant weight at 105^{o}C and reweighed, to get the difference in weights.

Data were processed using MS excel program. The mean and standard errors of the values of the variables were calculated and are presented in form of table.

4.2. FISH CATCH

Fish catch surveys were carried out at the two transects (Kalange-Makwanzi and Buyala-Kikubamutwe), throughout October 2007. Each transect was sampled on two days in each week, i.e. Monday/Tuesday and Thursday/Friday for four weeks starting 29th September 2007 to 28th October 2007. A replacement sampling day was considered in case an appointed day for sampling was missed due to unavoidable circumstances. The sampling of catches was carried out by one NaFIRRI Technician helped by a person selected from the nearby fisher communities.

A recognised fishing unit, comprising of a boat, fishing gears and fisher(s) was the basic sampling unit. For each sampled fishing unit the information recorded included: the date of sampling, boat type, type of propulsion, number of crew, number of days the fisher goes out fishing per week, the time of fishing (day/night), the type, size and number of fishing gears per boat, the method of operation of the gears, the fish species caught, the total weight of individual fish species, and the sample total length of each fish species. Information on the unit price (shs/kg) of different fish species at the landing site was also recorded.

The essential parameters derived were:

1. The mean catch rates (kg per boat per day) estimated for boats at each transect.
2. The total fish catches. These were estimated using the mean catch rates and the total effort data from the frame survey carried out in September 2007 during the quarterly survey. The boat activity coefficient, i.e. the probability that a fishing boat of each gear type would be active on any day during the month was derived from the mean number of days fished in the last one week. The total catch was then estimated.
3. The beach value of the catch i.e. the gross income to fishers was estimated by raising the estimated total catch in each effort group by the mean unit price of each fish species landed.

Sample size

The surveys covered a total of 43 boat days at Kalange/Makwanzi and 42 boat days at Buyala/Kikubamutwe throughout the 4 weeks sampled (1 boat day being the count of a fishing boat sampled on one day irrespective of whether it has been sampled on the previous visits). The gear usage of the sampled boats at Kalange/Makwanzi was 8 cast net, 26 gillnet, 7 Hand line, and 2 long line boat days; whereas at Buyala/kikubamutwe it was 1 cast net, 7 gillnet, 14 Hand line, 19 long line and 1 scoop net boat days. Fishing gear usage was not consistent throughout the sampling period which made it difficult to analysis for the required parameters by gear type. Thus the catch rates were estimated at the boat level irrespective of the gear used.

5. RESULTS AND DISCUSSION

5.1. WATER QUALITY

The values (mean ± SE) of the physical-chemical variables and total suspended solids in transects 1 and 2 (Kalange and Buyala) in the Upper Victoria Nile waters, obtained during the present weekly monitoring (September/October 2007), are shown (Table 1). The values of the monitored variables from the two transects for the same sampling dates are placed besides each other for easy comparison.

Physical-chemical variables and total suspended solids (TSS)

The results show a wide range of water depths from 1.9±0.3 to 2.8±0.2 m in transect 1 (Kalange) and 1.5±0.2 to 4.0±0.9 m in transect 2 (Buyala), during the eight sampling dates. These imply that there were significant fluctuations in water depths, especially on particular dates, in transect 2 (Buyala) than in transect 1 (Kalange). Although rains may have contributed to fluctuations in water level, the periodic releases from the construction site appear to be the major cause of this phenomenon. It is important to note that such fluctuations in water levels may have impacts on the aquatic biota and water quality. The water conductivity values were generally within the ranges of Lake Victoria waters in both transect 1 and 2 except a few cases in transect 2. The few cases of elevated water conductivity in transect 2 e.g. the 123±5.7 µs/cm observed on 18/10/2007, are signs of introduction of some salts into the river through the activities at the construction site. Possible evidence of water contamination on this date (18/10/2007) of sampling was the dirty colour of water that was observed at Transect 2 (Buyala).

Table 1: The values (mean±SE) of physical-chemical variables and total suspended solids (TSS) at the immediate upstream (1) and downstream (2) transects of Bujagali Power Project construction site along the Upper Victoria Nile during different dates of September/October 2007.

	TD (m)		Cond. (µs/cm)		Temp. (°C)		DO (mg/L)		pH		SD (m)		TSS (µg/L)	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Date														
29/9/07	1.9±0.3	2.7±1.1	102.7±0.3	113.3.7±2.0	26.5±0.2	25.1±0.1	7.0±0.0	6.2±0.1	7.3±0.2	7.3±0.2	1.7±0.3	1.4±0.2	1666.7±464.0	5083.3±1970.3
10/10/07	2.6±0.4	1.5±0.2	105.0±0.0	106.3±0.7	25.6±0.2	26.3±0.1	7.8±0.1	6.8±0.2	6.6±0.1	6.7±0.4	1.6±0.3	1.0±0.0	5116.7±1121.1	10833.3±1445.8
13/10/07	2.3±0.4	3.2±1.6	101.7±0.9	105.7±0.9	25.7±0.1	25.6±0.1	7.6±0.4	7.1±0.3	7.2±0.0	7.5±0.1	1.7±0.3	1.2±0.1	1750.0±381.9	2416.7±220.5
15/10/07	2.2±0.5	3.1±1.5	101.7±0.9	105.7±0.7	25.7±0.1	26.0±0.0	7.1±0.2	6.6±0.1	6.8±0.0	7.0±0.1	1.9±0.4	0.9±0.1	1583.3±300.5	8000.0±3538.5
18/10/07	2.3±0.4	3.1±1.5	102.7±0.3	123.0±5.7	26.6±0.0	26.7±0.1	7.5±0.1	6.5±0.3	7.1±0.0	7.1±0.0	2.1±0.3	1.1±0.1	1333.3±300.5	3750.0±763.8
20/10/07	2.6±0 4	4.2±2.5	107.3±0.3	107.7±0.3	25.7±0.1	25.5±0.0	6.5±0.2	6.3±0.4	7.3±0.0	7.5±0.0	1.2±0.1	1.1±0.3	3416.7±650.9	3833.3±1685.3
24/10/07	2.3±0.4	3.2±0.9	102.3±0.3	107.3±0.7	26.3±0.0	26.4±0.1	7.1±0.1	7.6±0.2	7.4±0.0	7.1±0.0	1.9±0.1	2.0±0.2	2000.0±500.0	7750.0±250.0
28/10/07	2.8±0.2	4.0±0.9	105.3±0.3	109.7±0.7	26.3±0.0	26.4±0.1	7.3±0.1	6.4±0.2	6.8±0.0	7.6±0.1	1.8±0.2	1.3±0.2	2083.3±83.3	8250.0±250.0

TD = Water depth, Cond. = Water conductivity, Temp. = Water temperature, DO = Dissolved oxygen, SD = Secchi depth, TSS = Total suspended solids

1 = Kalange transect, 2 = Buyala transect

SE = Standard error

Water temperature values in both transects were about 26°C and only slightly varied during the eight days of sampling. Probably temperature changes in water, arising from the construction site were still insignificant. The values of dissolved oxygen (DO) ranged from 6.5±0.2 to 7.8±0.1 mg/L in transect 1 (Kalange) and 6.3±0.4 to 7.6±0.2 mg/L in transect 2 (Buyala). The DO values in transect 1 were generally above 7.0 mg/L as compared to those of transect 2, that were in most cases below 7.0 mg/L. As explained in other studies (Allan 1995), reduced concentrations of DO downstream of an impoundment across a river is expected. The water that was being released could have had some DO depletion, especially in the deeper layers at the construction sites. Although the present levels of DO observed at transect 2 was still sufficient to support aquatic life, it was shifting towards the lower side. The pH values were about 7.0 in both transects 1 and 2, with insignificant variations during the eight days of sampling. Since photosynthetic activity in such a lotic environment is very minimal, pH values are not expected to vary much

The values of secchi depth as an indicator of water clarity was between 1.2±0.1 to 2.1±0.3 m in transect 1 and 0.9±0.1 to 2.0±0.2 m in transect 2. During most of the days of sampling, the secchi values in transect 2, were significantly lower that those in transect 1. This could be attributed to the presence of total suspended solids (TSS) in water that were significantly higher in transect 2 (Buyala) than in transect 1 (Kalange), during all the sampling dates. The values of TSS in transect 2, that ranged from 2416.7±220.5 to 10833.3±1445.8 µg/L in the present survey, are as well, in most cases significantly higher than those reported for the same transect during the recent quarterly survey of 2007, and that of 2006 (NaFIRRI 2006). This indicates that entry of solids especially sediments into the river, is becoming very prominent. Run offs from the highly cleared river banks could be a factor to this but the significant high concentrations of TSS at transect 2 than transect 1, suggests that the hydropower construction site is the likely main contributor to the elevated levels of this contaminant in the river. This short period (weekly) monitoring indicates how contaminants like sediments are entering the river at short intervals and this may not be easy to establish through long period (quarterly) monitoring, which is conducted when most of the contaminants have been transported or settled along the river. Sedimentation or siltation of an aquatic system may lead to adverse effects on the both micro and macro habitats and the entire physical conditions for the biota. This requires attention in terms of proper mitigation measures as the construction activities progress.

5.2. FISH CATCH

Species composition of catches

Twelve fish taxa which included *Lates niloticus, Oreochromis niloticus,* Haplochromines, *Bagrus docmak, Protopterus aethiopicus, Clarius gariepinus, Barbus altianalis, Mormyrus kannume, Tilapia zillii, Oreochromis variabilis, Oreochromis leucostictus, and Synodontis afrofishcheri* were recorded in the catches at Kalange/Makwanzi. Of the fish taxa recorded at Kalange, Haplochromines, *Protopterus aethiopicus, Oreochromis leucostictus, and Synodontis afrofishcheri* were missing in the catches at Buyala but one additional species, *Rastrineobola argentea,* was recorded in Week 1.

Fish catch rates

The fish catch rates were generally higher at Kalange/Makwanzi, upstream of the dam construction site compared with the catch rates at Buyala/Kikubamutwe (Tables 1&2). The overall monthly fish catch rates (all fish species pooled) was 9.6 kg/boat/day at Kalange/Makwanzi compared with between 5.0 kg/boat/day at Buyala Kikubamutwe. The weekly fish catch rates through October 2007 showed an upward trend at Kalange/Makwanzi whereas a downward trend was observed at Buyala Kikubamutwe down stream of the dam construction site (Figure 1). Apart from week 2, the overall catch rates were highest at Kalange/Makwanzi.

Table 1. Fish catch rates (kg/boat/day) at Kalange/Makwanzi in October 2007

Data	Week 1	Week 2	Week 3	Week 4	Overall
Lates niloticus	0.15	0.08	2.05	0.50	0.82
Oreochromis niloticus	1.18	0.33	0.25	1.61	0.91
Rastrineobola argentea	-	-	-	-	-
Haplochromines	0.17	-	-	0.25	0.12
Bagrus docmak	0.05	-	0.29	0.34	0.20
Protopterus aethiopicus	-	0.40	-	0.45	0.19
Clarius gariepinus	-	-	-	0.06	0.02
Barbus altianalis	0.45	1.07	1.45	5.48	2.36
Mormyrus kannume	0.99	4.42	1.12	2.65	2.01
Tilapia zillii	1.16	-	0.60	5.00	1.99
Oreochromis variabilis	1.79	0.63	0.55	0.85	0.97
Oreochromis leucostictus	-	-	-	0.04	0.01
Synodontis afrofishcheri	0.05	-	-	0.01	0.01
Overall	6.00	6.93	6.31	17.21	9.61

Table 2. Fish catch rates (kg/boat/day) at Buyala/Kikubamutwe in October 2007

Data	Week 1	Week 2	Week 3	Week 4	Overall
Lates niloticus	0.30	0.10	0.53	0.53	0.40
Oreochromis niloticus	0.07	-	-	-	0.02
Rastrineobola argentea	3.27	-	-	-	0.86
Haplochromines	-	-	-	-	-
Bagrus docmak	0.56	0.26	1.56	1.80	1.15
Protopterus aethiopicus	-	-	-	-	-
Clarius gariepinus	-	0.90	-	-	0.15
Barbus altianalis	0.68	6.49	1.33	0.73	1.85
Mormyrus kannume	0.73	0.64	0.02	0.60	0.48
Tilapia zillii	-	0.04	0.12	-	0.04
Oreochromis variabilis	-	0.07	0.06	0.02	0.03
Oreochromis leucostictus	-	-	-	-	-
Synodontis afrofishcheri	-	-	-	-	-
Overall	5.61	8.50	3.62	3.67	4.97

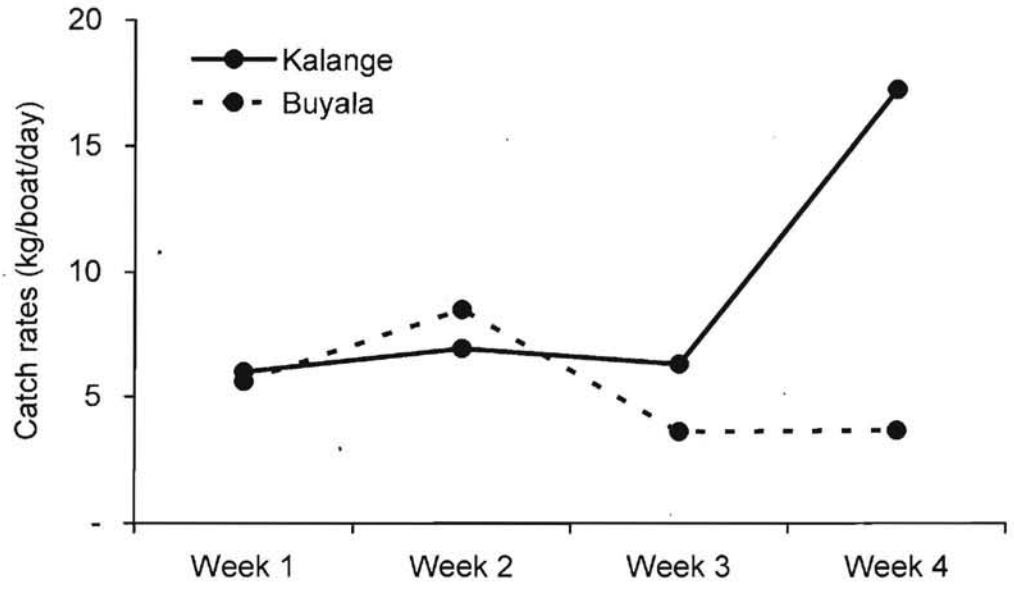

Figure 1. Trends of overall fish catch rates (all species pooled) at Kalange/Makwanzi and Buyala/Kikubamutwe in October 2007.

Estimates of total fish catches

The total catch estimates are influenced by the total fishing effort expended at the respective transects. In the Frame survey conducted at the two transects in September 2007 (NaFIRRI 2007) Kalange/Makwanzi had 10 fishing boats compared with 17 boats at Buyala/Kikubamutwe.

Thus Kalange with higher catch rates had slightly less total catch estimates (2,296.5 kg) compared with Buyala/Kikubamutwe (2,400.7 kg) for October 2007 (Tables 3&4).

Table 3. The estimated total fish catches (kg) at Kalange/Makwanzi for October 2007

Data	Week 1	Week 2	Week 3	Week 4	Total
Lates niloticus	9.7	5.3	128.9	31.3	175.2
Oreochromis niloticus	74.5	21.0	16.0	101.3	212.7
Haplochromines	10.9	-	-	15.8	26.6
Bagrus docmak	2.9	-	18.4	21.3	42.6
Protopterus aethiopicus	-	25.2	-	28.1	53.3
Clarius gariepinus	-	-	-	3.6	3.6
Barbus altianalis	28.6	67.2	91.4	345.0	532.2
Mormyrus kannume	62.4	278.3	70.3	166.7	577.7
Tilapia zillii	73.3	-	37.8	315.0	426.1
Oreochromis variabilis	112.8	39.9	34.7	53.3	240.7
Oreochromis leucostictus	-	-	-	2.4	2.4
Synodontis afrofishcheri	2.9	-	-	0.5	3.3
Overall	378.0	436.8	397.4	1,084.3	2,296.5

Table 4. The estimated total Fish catches (kg) at Buyala/Kikubamutwe for October 2007

Data	Week 1	Week 2	Week 3	Week 4	Total
Lates niloticus	33.2	11.2	58.9	59.4	162.6
Oreochromis niloticus	7.7	-	-	-	7.7
Rastrineobola argentea	367.2	-	-	-	367.2
Bagrus docmak	63.2	28.9	175.3	201.5	468.9
Protopterus aethiopicus	-	-	-	-	-
Clarius gariepinus	-	101.0	-	-	101.0
Barbus altianalis	76.5	727.7	149.6	81.3	1,035.1
Mormyrus kannume	81.6	72.1	2.3	67.3	223.4
Tilapia zillii	-	4.8	13.1	-	17.9
Oreochromis variabilis	-	8.0	7.0	1.9	16.9
Overall	629.3	953.7	406.3	411.4	2,400.7

Estimates total beach value of the catch

The gross value of the fisheries at the two transects for October 2007 was estimated at shs 2.4 million at Kalange/Makwanzi and shs 2.6 million at Buyala Kikubamutwe (Tables 5&6).

Table 5. The estimated gross value (shs) of the fish catches at Kalange/Makwanzi in October 2007

Data	Week 1	Week 2	Week 3	Week 4	Total
Lates niloticus	12,436	6,706	164,650	39,925	223,717
Oreochromis niloticus	87,750	24,750	18,848	119,371	250,719
Haplochromines	7,617	-	-	11,025	18,642
Bagrus docmak	3,782	-	24,324	28,164	56,270
Protopterus aethiopicus	-	15,750	-	17,567	33,317
Clarius gariepinus	-	-	-	4,180	4,180
Barbus altianalis	36,019	84,525	114,901	434,003	669,449
Mormyrus kannume	54,624	243,469	61,486	145,869	505,447
Tilapia zillii	72,262	-	37,260	310,500	420,022
Oreochromis variabilis	110,620	39,119	33,972	52,265	235,976
Oreochromis leucostictus	-	-	-	2,423	2,423
Synodontis afrofishcheri	3,580	-	-	606	4,185
Total	388,690	414,319	455,441	1,165,898	2,424,348

Table 5. The estimated gross value (shs) of the fish catches at Buyala/Kikubamutwe in October 2007

Data	Week 1	Week 2	Week 3	Week 4	Total
Lates niloticus	42,342	14,331	75,238	75,835	207,745
Oreochromis niloticus	9,016	-	-	-	9,016
Rastrineobola argentea	91,800	-	-	-	91,800
Bagrus docmak	83,530	38,108	231,559	266,138	619,334
Clarius gariepinus	-	116,127	-	-	116,127
Barbus altianalis	96,223	915,307	188,169	102,317	1,302,015
Mormyrus kannume	71,400	63,113	2,045	58,905	195,463
Tilapia zillii	-	4,740	12,903	-	17,643
Oreochromis variabilis	-	7,857	6,875	1,833	16,566
Total	394,310	1,159,582	516,789	505,028	2,575,709

6. DISCUSSION

The results from the present monitoring at short time intervals (weekly), conducted at transects 1 and 2 (Kalange and Buyala, respectively), during September/October 2007, show larger fluctuations in water depth; some cases of elevated water conductivity, reduced dissolved oxygen during most of the days; low water clarity (SD); and significantly high concentrations of total suspended solids in Buyala than in Kalange. The temperature and pH values obtained from both Kalange and Buyala, during all the days of sampling, were quite similar. This monitoring has

revealed that contaminants like sediments which enter the river at short time intervals may not be detected through the long term quarterly monitoring surveys, which are conducted when most of the contaminants have been transported away or settled at the river bed. Therefore, the short time interval (weekly) monitoring of the river during the BEL Project is highly recommended to supplement the findings of the quarterly monitoring.

The fisheries upstream at Kalange/Makwanzi and downstream of the dam construction site at Buyala/Kikubamutwe are quite different with regard to the gears used and the species caught which is probably dictated by the different water flow regimes. This may render direct comparison of the fisheries at the two sites inappropriate. However, irrespective of that fact, the short-term results collected weekly through October 2007 indicate a reduction in catch rates at Buyala/Kikubamutwe which may be associated with the activities at the dam construction site. The fishers at Buyala attributed the decreasing catches to the frequent occurrence of very turbid water and large fluctuations in water level as the major factors affecting fish catches. The fisher for *R. argentea* was only encountered once in the first week and did not operate in the subsequent weeks. Whereas it was not possible to locate him for an interview on why he had stopped fishing, the frequently turbid waters could have affected catches since this fishery depends on light attraction. Other none fishery domestic water uses at Buyala like washing, cooking have also been affected by water turbidity. Firm conclusions may not be deducted from the weekly monitoring covering only one month. These surveys should be supported over a longer time of more regular to improve the integrity of the observations and understanding of the project's short-term impacts.

7. CONCLUSION AND RECOMMENDATIONS

A major conclusion from the monthly observations is that Transect 2 (downstream) of the Project site) showed apparent impacts of the project on water quality and the fish catch. There were noticed variations in water depth across the sampled transects. The differences were likely a result of upstream water regulation. There was evidence of increased turbidity which could be related to an increase in total suspended solids and water conductivity when compared to results from the earlier conducted quarterly sampling. Water colour (brown) was clearly a result of input from civil works around the construction site.

Fish catch characteristics at Transect 1 (Upstream of the Project site) differ from what is observed downstream of the Project site (Transect 2) in terms of gears and species targeted. However, observations through October 2007 suggest a general reduction in catch rates in

comparison to previous sampling periods. These observations were corroborated by fisherfolk at Transect 2 who seemed skeptical about earlier promises under AES to have their interests protected. It is recommended that the project engages more with residents in the affected areas to address their concerns, and, similarly, the Project commissions a more rapid assessment of fisher community perceptions about on-going activities.

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